Design and Development of a Low Cost, Manufacturable High Voltage Power Module for Energy Storage System

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DOE Energy Storage Program – Phase II SBIR

Background

Objective

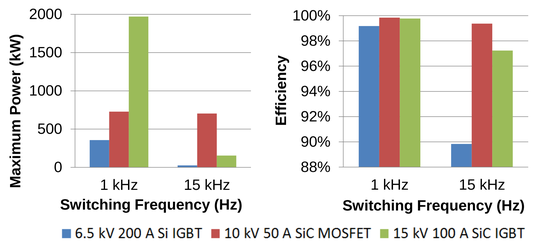
Develop a high voltage (> 15kV) silicon carbide (SiC) power module to aid in the emergence of smarter, seamless powered grids.

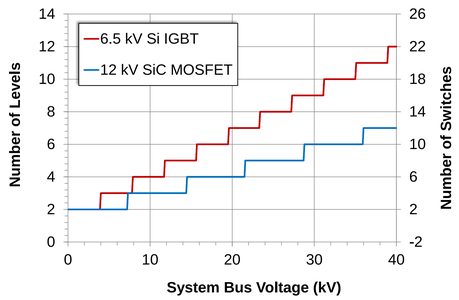
Applications

- Energy storage systems
- Solid-state transformers
- Naval power distribution
- Electric locomotives
- Solid-state circuit breakers

Advantages

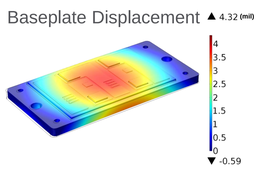
- Reduce size/complexity compared to multi-level system
- Eliminate cooling systems
- Increase efficiency and power density

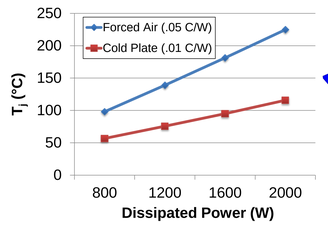


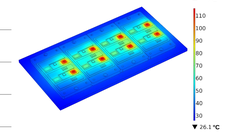


Results

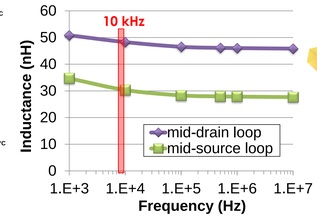
Thermal, Electrical, Mechanical Simulations

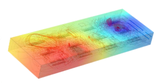






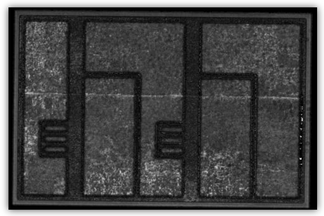
R_{jc} < 0.03 °C/W





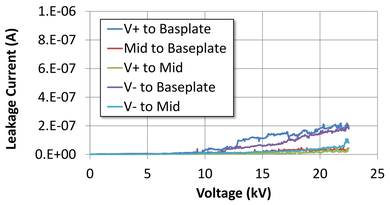
At 10 kHz
L_1 = 48 nH
L_2 = 30 nH

Power Module Assembly Development



Low void power substrate attach (< 5 % voids)

Low void Ag sinter die attach



Low leakage current up to 22.5 kV

Approach

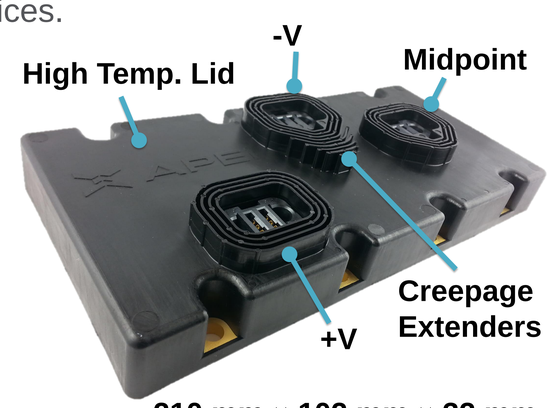
Design a high performance power module that will take full advantage of the superior properties of high voltage SiC devices.

Advantages of SiC Devices

- High breakdown voltage
- High thermal conductivity
- High switching frequency
- High temperature operation

Power Module Features

- Device neutral
- Low profile
- Reduced volume/weight
- High temperature capable (200 °C)

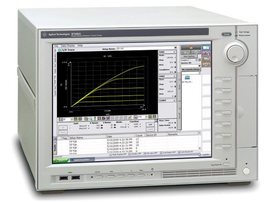


210 mm × 102 mm × 32 mm
15 kV / +100 A

Future Work

Power Module Static Testing

- Gate leakage
- Reverse leakage
- On-state curves
- On resistance
- Transconductance



Power Module Dynamic Testing

- Turn-on and -off delay time
- Rise and fall time
- Turn-on and -off over voltage
- Switching loss

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APEI

U.S. DEPARTMENT OF ENERGY

Sandia National Laboratories